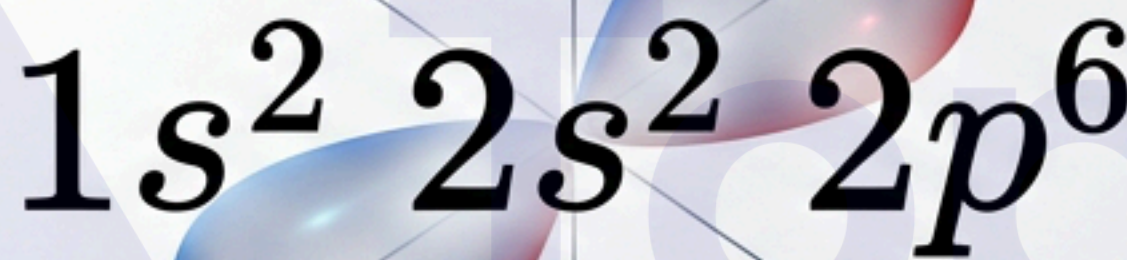


2.6.4 Filling of Orbitals in Atom



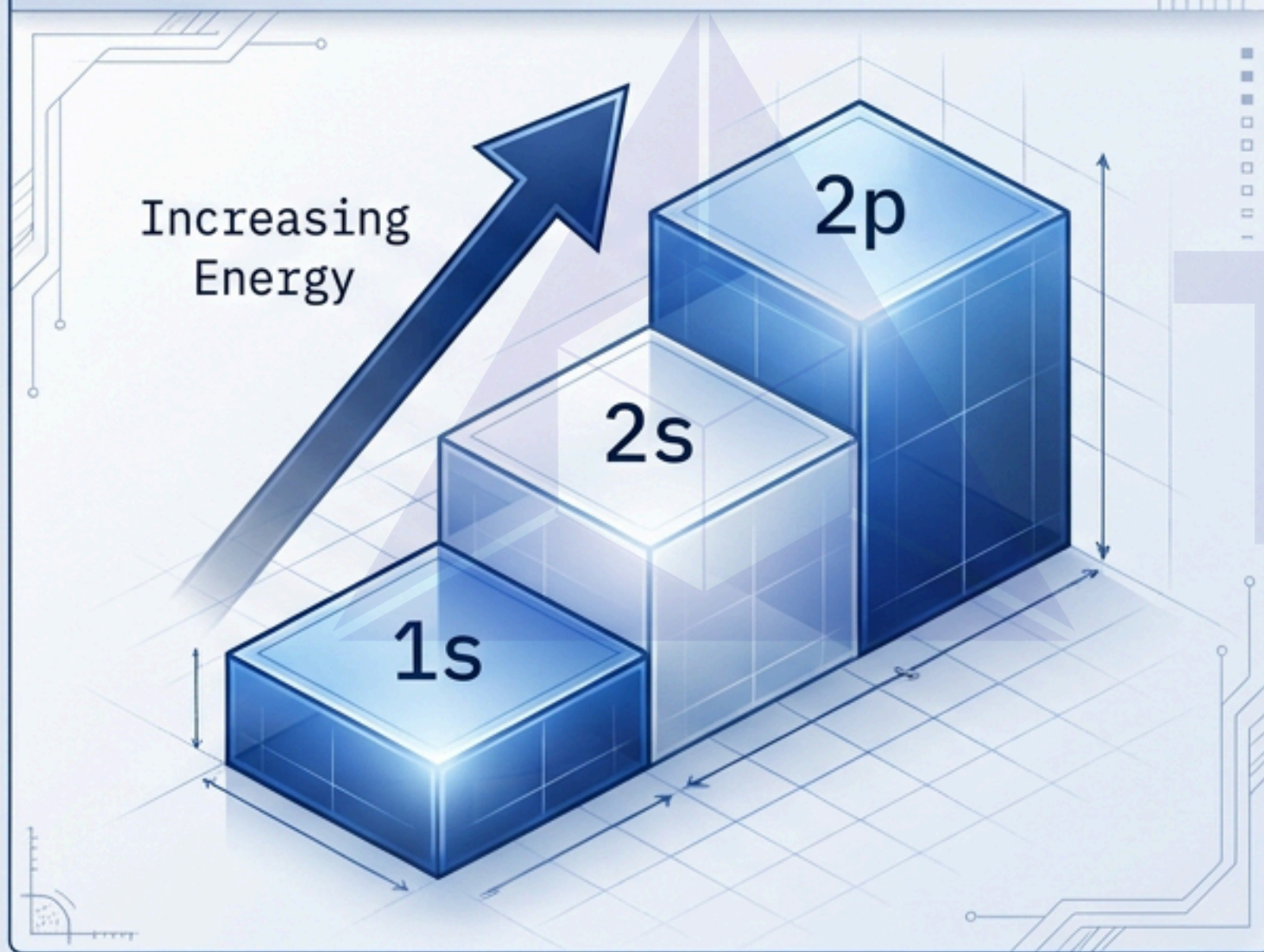
The Energy Code (Aufbau)

The Occupancy Limit (Pauli)

The Degeneracy Etiquette (Hund)

The Aufbau Principle

The Energy Hierarchy



The Rule

“Aufbau” is German for ‘building up’.

Electrons first occupy the lowest energy orbital available before entering higher energy orbitals.

The Mechanism

Energy is determined by the $(n+1)$ rule.

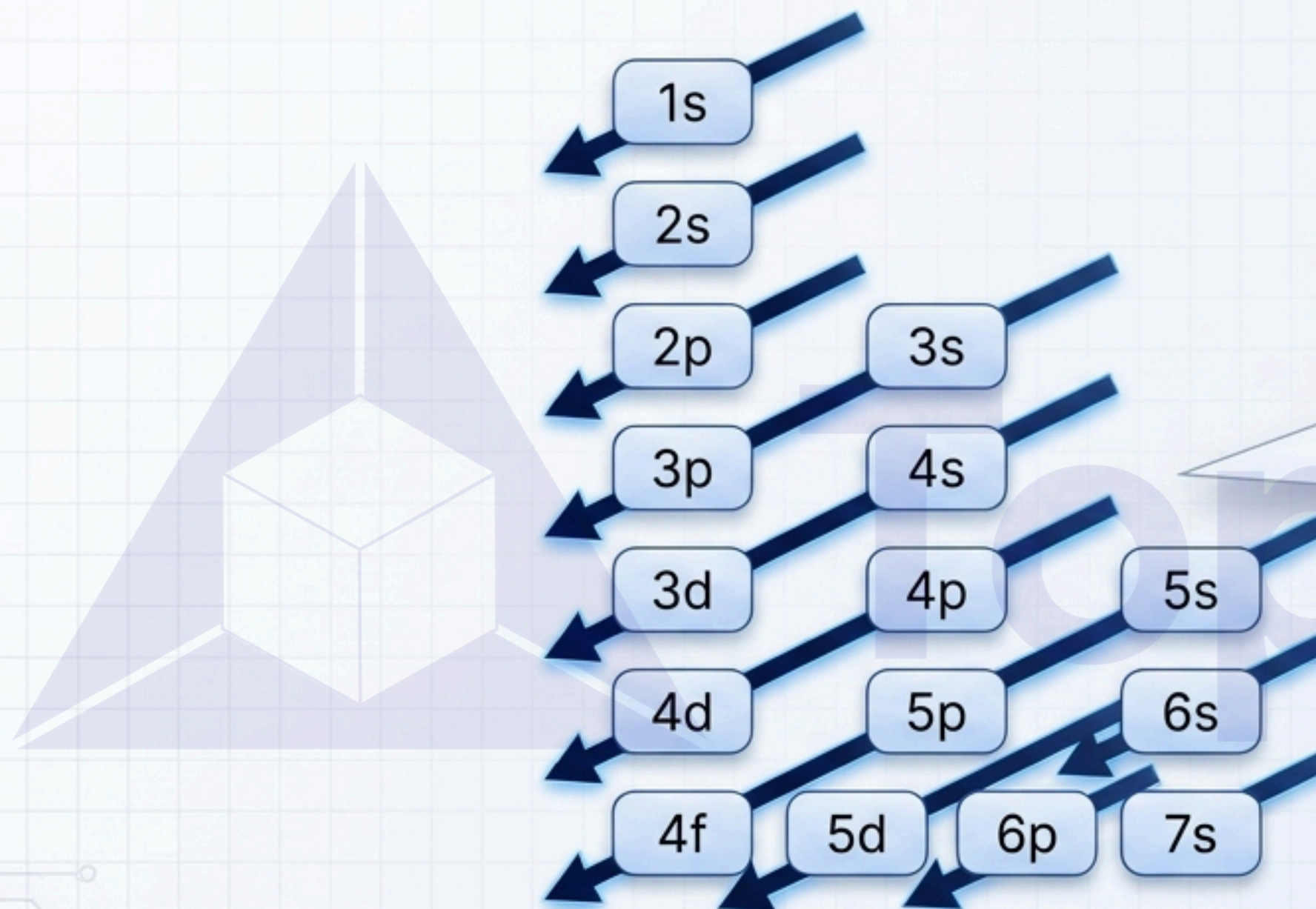
Lower $(n+1)$ value = lower energy.

If values are equal, the lower n fills first.

$4s$ ($n=4, \ell=0 \rightarrow 4$) is lower energy than $3d$ ($n=3, \ell=2 \rightarrow 5$). Therefore, $4s$ fills before $3d$.

Electrons always seek the most stable (lowest energy) ground floor available.

The Order of Orbital Filling



The Transition Metal Shift

Notice the arrows cross 4s before 3d. The 4s orbital is lower in energy, so the valence electron in Potassium (K) goes to 4s, not 3d.

→ 1s → 2s → 2p → 3s → 3p → 4s → 3d → 4p → 5s → 4d → 5p → 6s →

Follow the diagonal arrows: energy levels overlap as atomic size increases, creating a strict, non-linear filling sequence.



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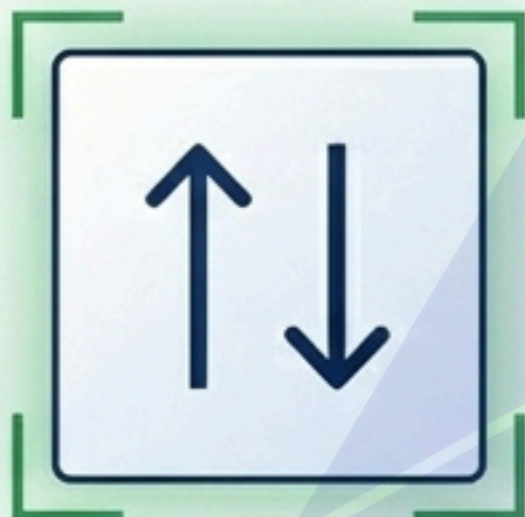
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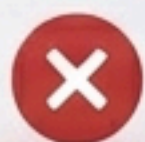


Pauli Exclusion Principle

Pauli Exclusion Principle



Correct:
Opposite Spins



Incorrect:
Identical Spins

The Rule

No two electrons in an atom can have the exact same set of four quantum numbers (n, l, m_l, m_s).

The Translation

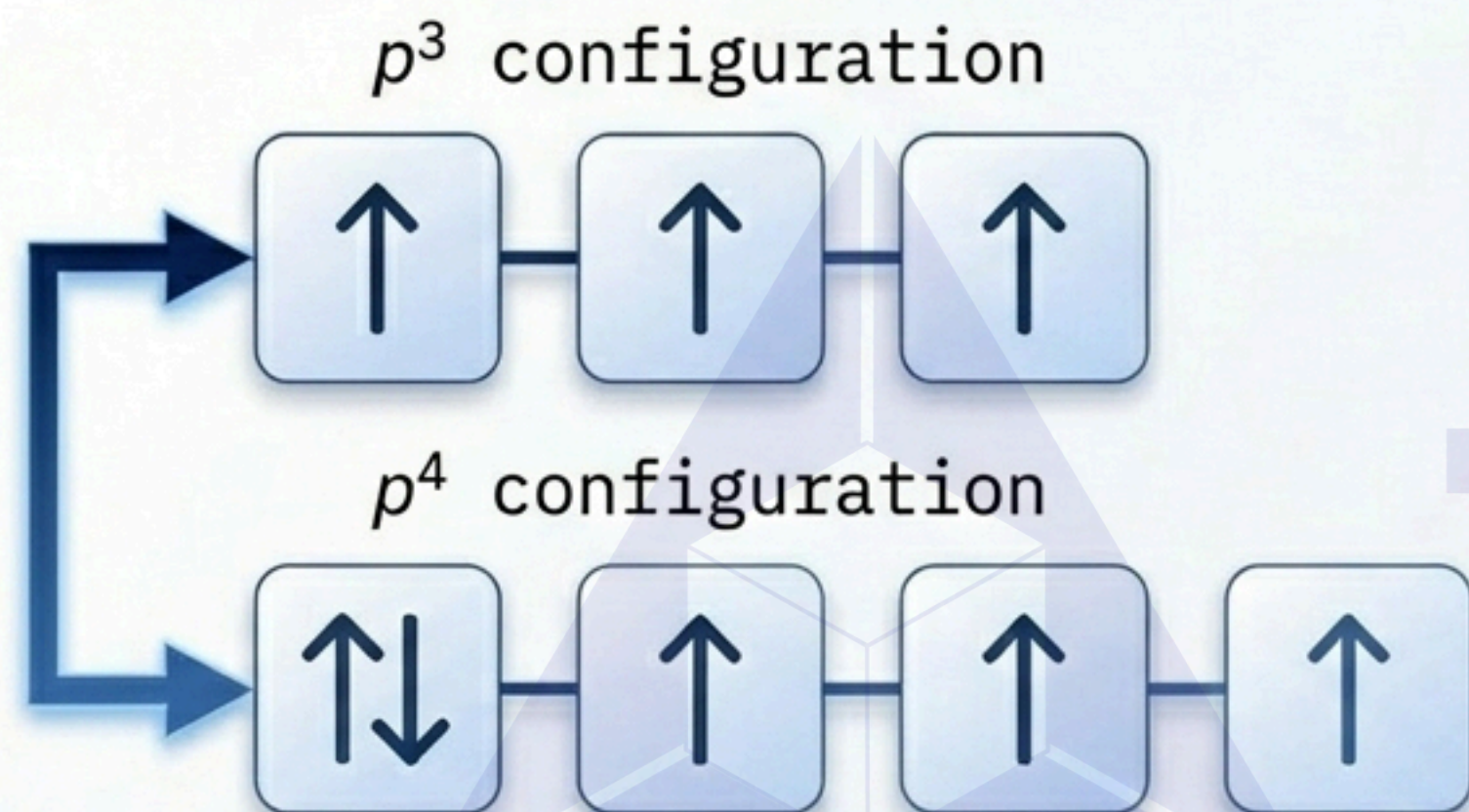
A single orbital can hold a maximum of two electrons, and they must have opposite spins.

Electron 1:
 $m_s = +\frac{1}{2}$ (↑)

Electron 2:
 $m_s = -\frac{1}{2}$ (↓)

Orbitals are strictly double-occupancy, and the occupants must spin in opposite directions to coexist.

Hund's Rule of Maximum Multiplicity



The Rule

Pairing in degenerate subshells (p, d, f) does not take place until each orbital is singly occupied with parallel spins.

The Reason

Extra Stability.

Half-filled and fully-filled subshells minimize coulombic repulsion, maximize symmetrical distribution, and maximize Exchange Energy.

Degenerate Orbitals

Orbitals belonging to the same subshell with the exact same energy (e.g., p_x , p_y , p_z).

Electrons maximize space and symmetry—they claim empty degenerate orbitals before agreeing to share.

Shell & Subshell Capacity

Subshell (ℓ)	Number of Orbitals ($2\ell+1$)	Max Electrons
s (0)	1	2
p (1)	3	6
d (2)	5	10
f (3)	7	14

The Shell Formula

$$2n^2$$

The maximum number of electrons in a principal shell n is governed by this mathematical limit.

For shell $n=3$, capacity = $2(3)^2 = 18$ electrons.
(Comprising one s, three p, and five d orbitals $\rightarrow 2 + 6 + 10 = 18$).

Pauli's rule of 2 electrons per orbital creates strict, predictable mathematical limits for the entire atom.

The Three Rules of Electron Configuration

Aufbau Principle

Governs: Energy Sequence

The Law: Lowest $(n+l)$ energy fills first.



Pauli Exclusion

Governs: Occupancy & Spin

The Law: Max 2 electrons per orbital, opposite spins.



Hund's Rule

Governs: Degenerate Orbitals

The Law: Singly occupy parallel spins before pairing.



Example Configuration: Nitrogen ($Z=7$) $\rightarrow 1s^2 2s^2 2p^3$
(Lowest energy first $\rightarrow$ 2 per s-orbital $\rightarrow$ 3 unpaired electrons in p-orbitals).

Aufbau builds the map. **Pauli** sets the limits. **Hund** dictates the behavior.



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